

Analysis of vertical shift in Band 6 of Landsat 5 images in the EROS L1T product

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Conclusion

Close inspection of L1T images processed for Landsat 5 (TM) by the EROS Center during 2007 indicates a systematic vertical downward shift of 30 to 90 m in the resampled band 6 (thermal band). Band 6 was resampled during the L1T process from the original 120 m to 30 m. The shift problem seems to occur for both cubic convolution and nearest neighbor resampling schemes.

Introduction

L1T images processed by the EROS Center for Landsat 5 (TM) during 2007 have been found to have a systematic vertical downward shift of 30 to 90 m in the resampled band 6 (thermal band). Band 6 was resampled during the L1T process from the original 120 m to 30 m. The shift problem seems to occur for both cubic convolution and nearest neighbor resampling schemes. The following analysis was conducted to quantify the distance of the shift. L1T TM images for path 39 in southern Idaho (year 2006) and for path 33 in western Nebraska (year 2002) that were processed in 2007 were evaluated. Both cubic convolution (CC) and nearest neighbor (NN) resampling procedures were evaluated for the Idaho image. NN only was used with the Nebraska image.

The nature of the shift is visually evident in the following Fig 1 (screen shot using ERDAS Imagine) for July 15, 2006 in path 39, where false color (bands 2,3,4) images of a center pivot irrigated field (diameter ~ 800 m) in southern Idaho are shown on the left and band 6 digital number (DN) images are shown on the right. The top row is where the L1T product was resampled by EROS using CC and the bottom row using NN. A vertical, downward shift on the order of 2 to 3 30-m pixel rows (60 to 90 m) for band 6 relative to bands 2, 3, 4 is evident.

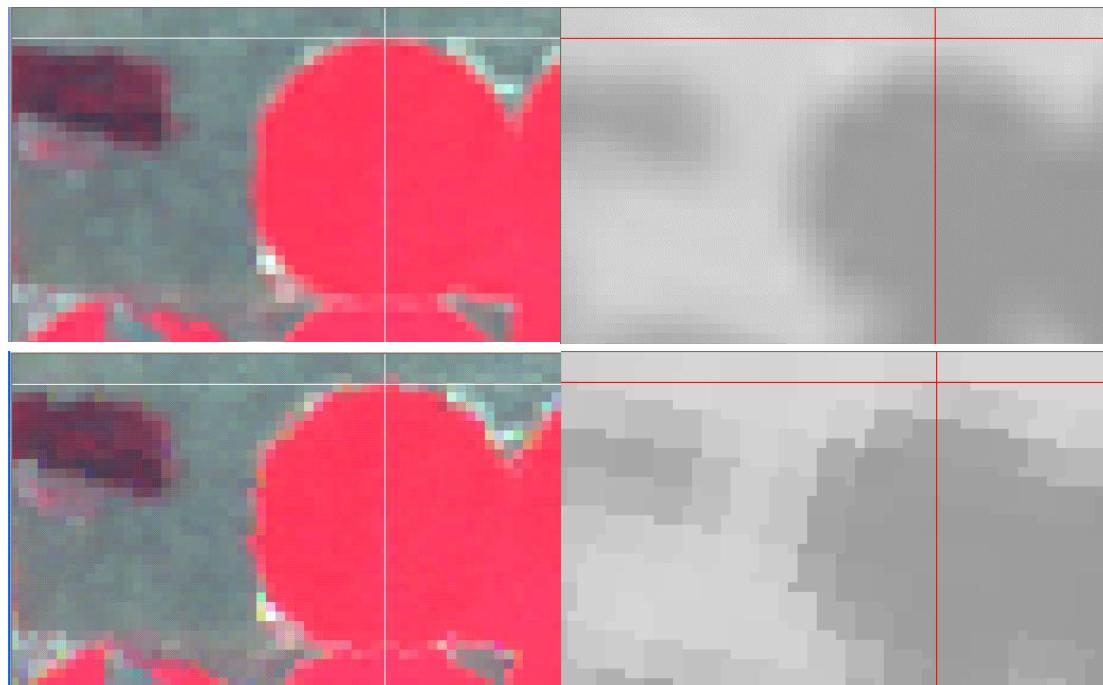


Fig. 1. False color (left column) (bands 2, 3, 4) and band 6 (right column) resampled to 30 m (by EROS L1T) using CC (top) and NN (bottom) for path/row 39/30, July 15, 2006 (Landsat 5).

The vertical shift of band 6 was not found for TM5 images in our (UI) holdings that were terrain corrected by Earthsat (MDA) prior to year 2007.

Procedure

The image evaluated for the shift effect for Idaho was ordered on Aug. 1, 2007 by Univ. Idaho, Order # 0110708010014 and was processed Aug 2, 2007, Work Order 011070801001700003 (see Appendix A for NLAPS Correction Processing Reports):

Path 39, row 30, (S.Idaho) – Image date: 7/15/2006

The image evaluated for Nebraska was processed on Oct. 22, 2007. The order was placed by the Univ. Nebraska, Work Order 080071017007300002:

Path 33, row31, (W.Nebraska) – Image date: 06/08/2002

The Idaho image (path 39) was projected by EROS to the “Idaho Transverse Mercator 83” (IDTM83) projection having the following attributes:

IDTM83

Datum: NAD 83

Scale factor: 0.99960 Units: meters

Central Meridian: -114 00 00, Latitude of Origin: 42 00 00

False Easting: 2,500,000, False Northing: 1,200,000

The Nebraska image (path 33) was projected by EROS to UTM Zone 13, NAD83.

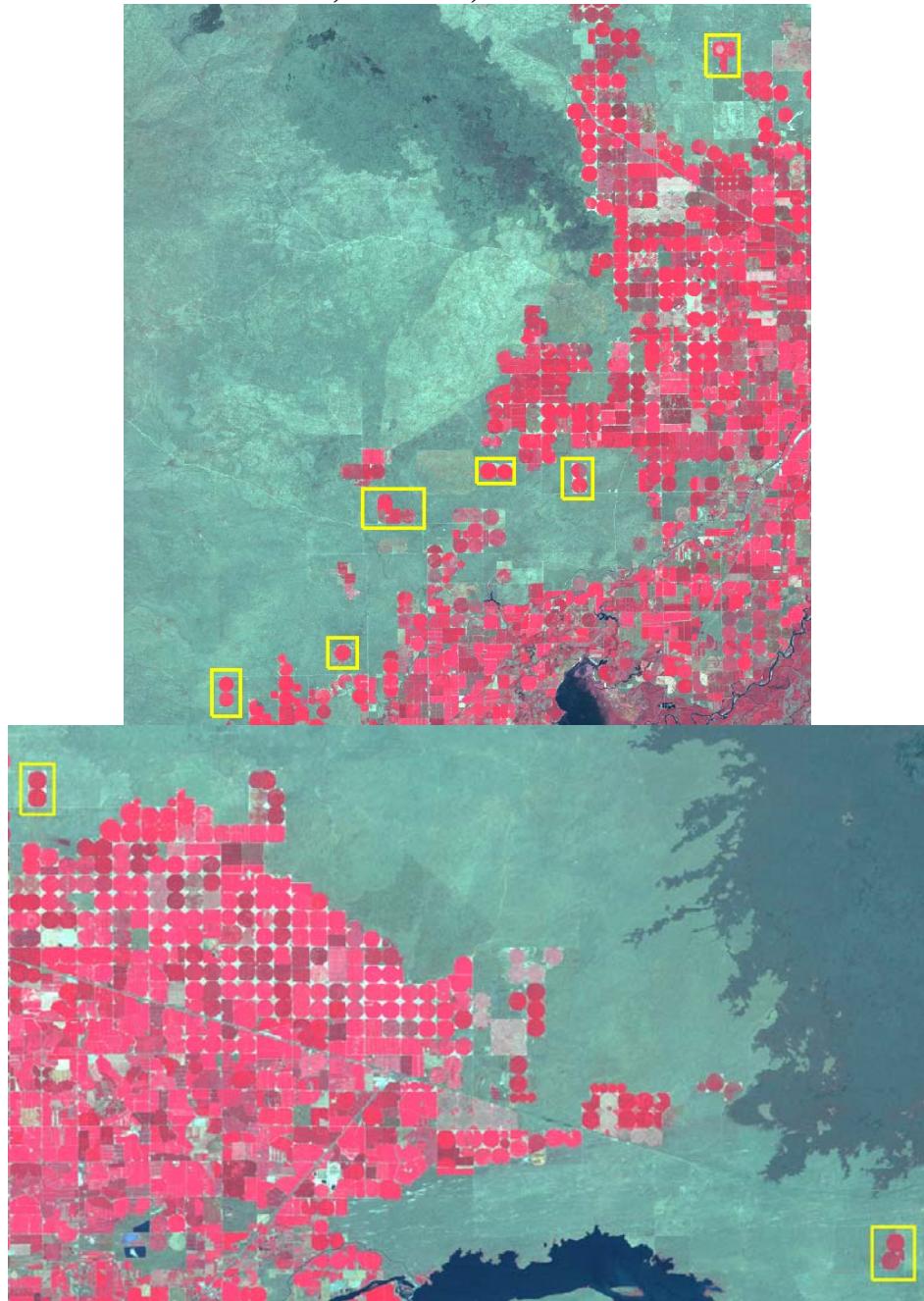
To investigate the nature of the thermal shift quantitatively, we identified a number of isolated irrigated fields (for Idaho) where large differences in land surface temperature (LST) exist between the fields and desert. Within these areas of interest (AOI's), we filtered those shortwave pixel locations that had normalized difference vegetation index (NDVI) greater than 0.25. This created ‘masks’ that laid over the vegetated portions of fields at the 30 m resolution. The vegetated areas within irrigated fields in Idaho typically have LST that are 15 to 30 K colder than those of the surrounding desert. NDVI of desert areas in S.Idaho is typically 0.15 or less during mid summer. In the case of the Nebraska image, we also evaluated LST shift for small water bodies that are typically colder than their surroundings.

During the analyses, band 6 of the stacked images was shifted upward, downward or side-ways by one 30-m pixel row at a time. Using ERDAS Imagine tools and customized Model-Maker coding, we averaged the band 6 DN for all 30 m pixels of band 6 that lay within the NDVI > 0.25 masks that overlaid isolated irrigated fields (usually center pivot fields of about 800 m diameter) surrounded by desert. Our hypothesis was that if band 6 was incorrectly and systematically shifted during georectification and resampling, then we would see a lowering of sampled band 6 DN when we shifted a specific number of rows up or down or left or right. The averaged band 6 over the masked areas that minimizes the average DN (and generally the standard deviation (SD)) would indicate the general extent of the spatial shift.

Results

The following section shows screen shots from ERDAS Imagine where selected AOI's (yellow rectangles) are shown. Summary statistics associated with these areas of interest are presented. In general the shift in band 6 appears to be about 60 to 90 m to the south (vertically downward) for the Southern Idaho image and 30 to 70 m for the Nebraska image.

Area 1, Path 39, row30 - Idaho

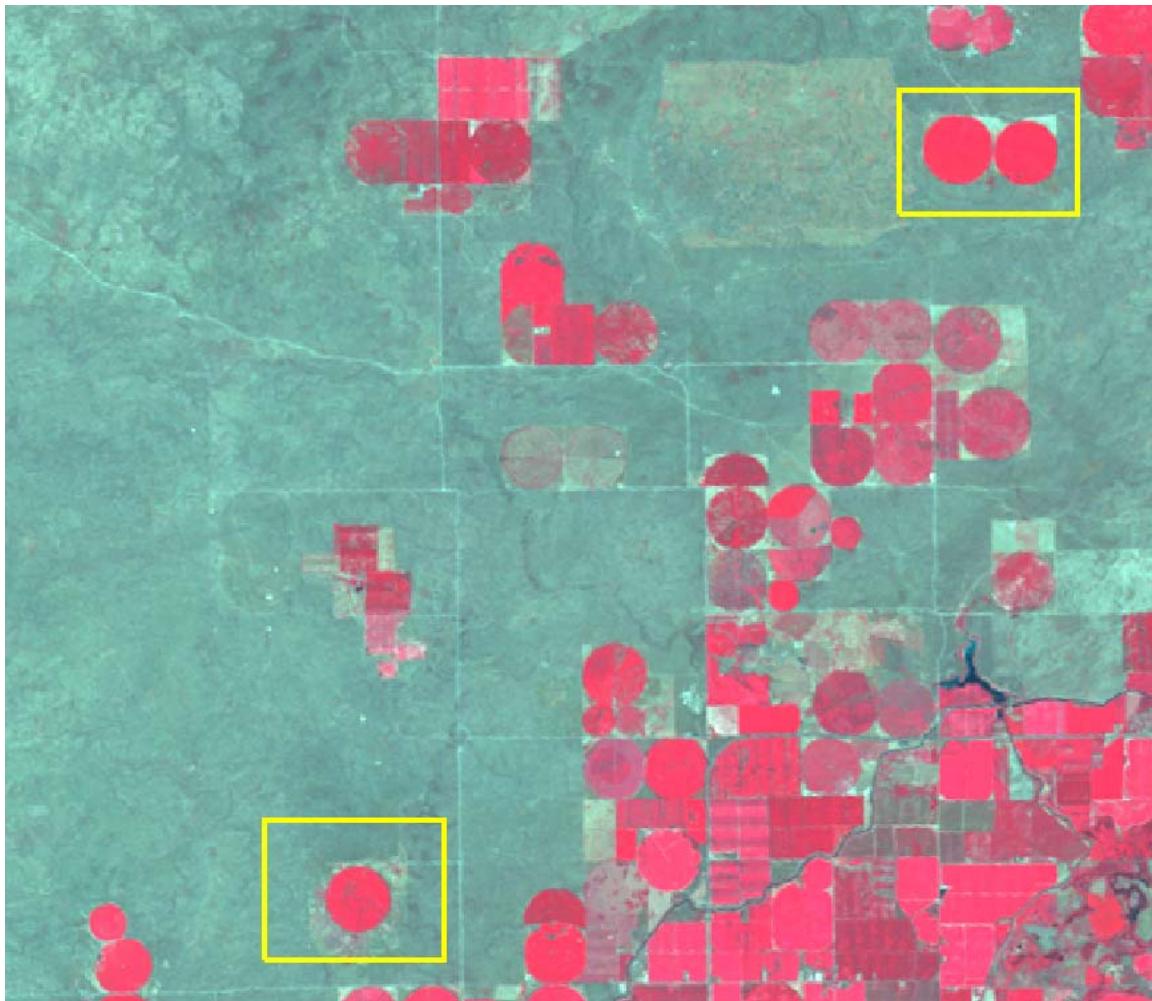


Mean and standard deviation of DN of band 6 for CC and NN, 8 AOI's in 39/30, 7-15-2006:

	CC - Mean	CC - SD	NN-Mean	NN-SD
Unshifted	150.943	12.378	152.353	13.414
30 left	151.292	12.682	152.079	13.120
30 right	151.035	11.881	151.596	12.394
30 down	151.997	13.764	153.10	14.056
30 m up	150.204	11.601	151.307	12.234
60m up	150.011	11.018	151.333	12.286
90m up	149.485	10.310	151.242	12.116
120m up	149.992	11.332	151.233	12.276

This analysis shows band 6 DN minimized (mean and SD) with a 90 m upward shift for both CC and NN, where mean DN was lowered by about 1.5 DN. No impact was found when band 6 was shifted to the left or right (or down). The mean DN increased slightly in all cases. Therefore the shift appears to be vertical, only.

Area 2 - path 39



Mean and standard deviation of DN of band 6 for CC and NN, 2 AOI's in 39/30, 7-15-2006:

	CC - Mean	CC - SD	NN-Mean	NN-SD
30m down	151.833	14.266	153.744	14.805
Unshifted	150.262	11.754	153.047	13.841
30 m up	148.756	9.838	150.878	11.896
60m up	148.049	7.678	149.756	10.156
90m up	148.610	9.617	150.81	12.134
120m up	151.095	13.501	150.275	11.741

This analysis evaluated only two of the AOI's in path 39/30 that were most isolated from other fields. Mean and standard deviation of DN of band 6 was minimized at 60 m for both CC and NN. The degrees of freedom may be too few to conclude the shift in this analysis.

Area 3 Path 39



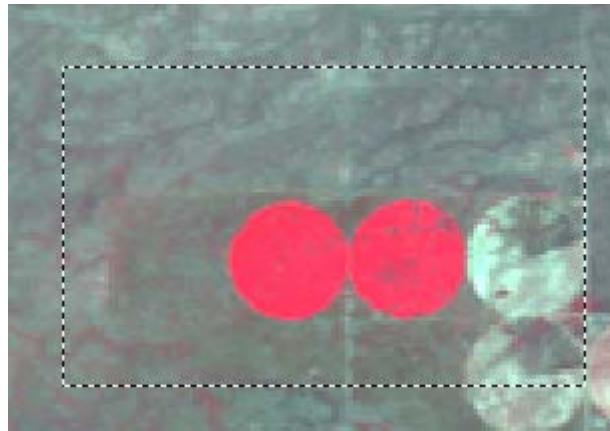
Mean and standard deviation of DN of band 6 for CC and NN, one AOI in 39/30, 7-15-2006:

	CC - Mean	CC - SD	NN-Mean	NN-SD
30m down	151.193	13.753	153.464	15.524
Unshifted	148.771	10.965	149.631	11.234
30 m up	149.193	11.116	150.679	12.676
60m up	148.735	10.553	149.988	11.080
90m up	148.771	10.965	149.631	11.234
120m up	149.108	11.847	150.250	12.359

This analysis evaluated only one AOI in path 39/30 that was most isolated from other fields. Mean and standard deviation of DN of band 6 was minimized at 60 to 90 m for both CC and NN. However, the degrees of freedom are too few to conclude the shift.

One additional analysis was made for a single, small area of two irrigated fields for **path 40** row 30 for June 20, 2006. This image was processed in the same order as image 39/40.

Area 1 – path 40



Mean and standard deviation of DN of band 6 for CC and NN, one AOI in Path 40, row 30, (S.Idaho) –
Image date: 6/20/2006

	CC - Mean	CC - SD	NN-Mean	NN-SD
30m down	143.463	13.816	143	13.204
Unshifted	142.841	13.470	142.619	12.982
30 m up	143.463	13.816	143	13.204
60m up	141.841	12.898	141.321	12.379
90m up	141.354	12.825	141	12.030
120m up	141.073	12.841	141	11.987

This analysis evaluated only one AOI in path 40/30 that was isolated from other fields. Mean and standard deviation of DN of band 6 was minimized at 90 to 120 m for both CC and NN. However, the degrees of freedom are too few to conclude the shift.

Nebraska path33row31–2002/06/08

Small lakes-

For the Nebraska image, we first used small water bodies (lakes) to investigate the nature of the thermal shift. We selected water bodies that did not have extensive wetland vegetation or other vegetation around their shore lines so that large differences in surface temperature (LST) should exist between the bodies and surrounding grassland. Within these areas of interest (AOI's), we filtered those shortwave pixel locations that had normalized difference vegetation index (NDVI) less than 'x', where $x = 0.0, 0.05$ and 0.1 , to isolate the water bodies. This created 'masks' that laid over the water bodies at the 30 m resolution. About ten water body AOI's were created. Results are as follow:

Nebraska NDVI <0

	NN-Mean	NN-SD
30m down	132.622	9.215
Unshifted	131.757	7.776
30 m up	130.541	5.237
60m up	131.216	6.395
90m up	131.135	6.820
120m up	131.892	7.508

Nebraska NDVI <0.05

	NN-Mean	NN-SD
30m down	134.125	10.353
Unshifted	133.075	8.862
30 m up	131.725	6.771
60m up	131.925	6.848
90m up	131.850	7.224
120m up	132.550	7.766

Nebraska NDVI <0.1

	NN-Mean	NN-SD
30m down	135.438	11.110
Unshifted	134.563	10.108
30 m up	132.792	7.680
60m up	132.896	7.763
90m up	133.563	8.994
120m up	134.146	9.255

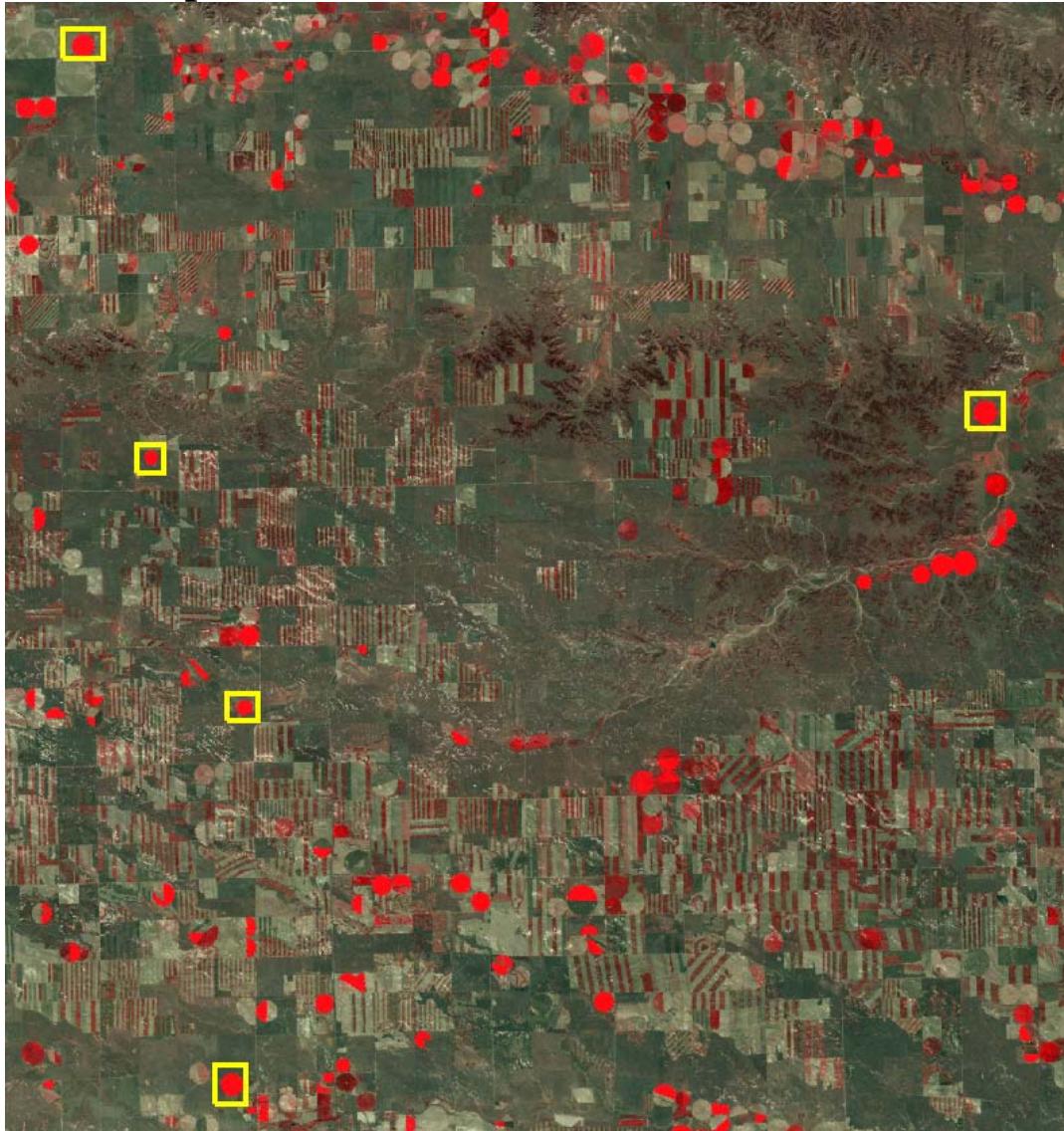
For all three water body masks, the mean DN and standard deviation of DN was minimized at about 30 m, with a plateau extending to 60 m. This suggests about 30 to 60 m downward shift for this Nebraska image.



Vegetated Fields

The Nebraska image (33/31) was further investigated using isolated irrigated fields, similar to what was done with the Idaho images. Ten AOI's were identified as shown in the following two figures.

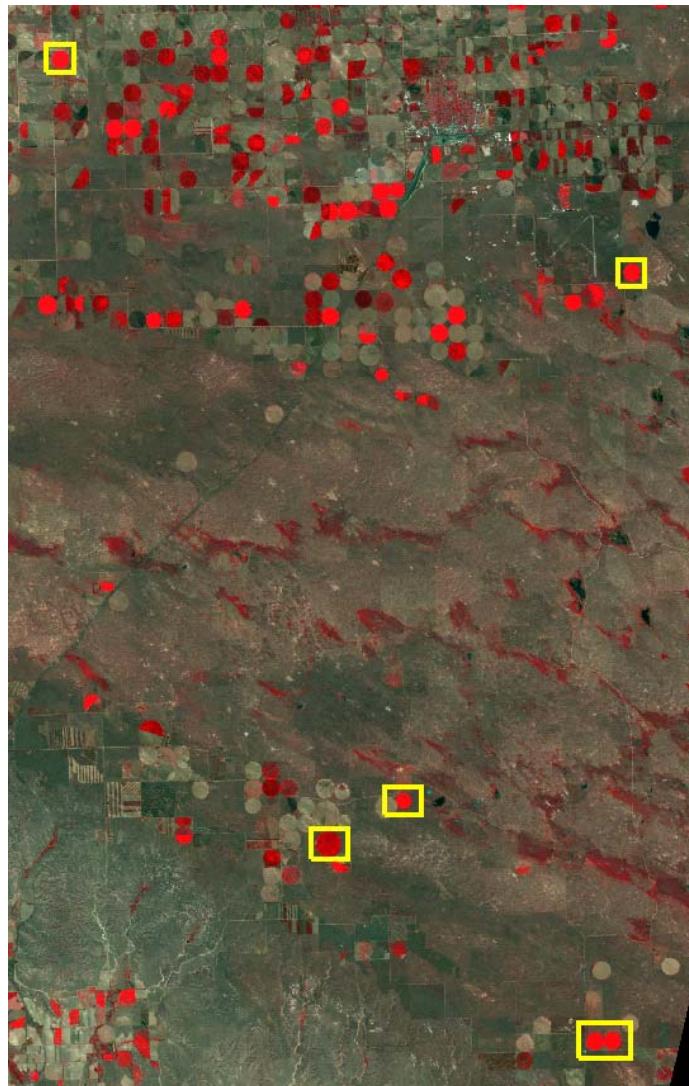
Nebraska path33row31– Isolated Center Pivots -2002/06/08



	NN-Mean	NN-SD
30m down	150.0	11.797
Unshifted	148.615	8.874
30 m up	147.308	8.489
60m up	147.846	8.484
90m up	148.615	8.874
120m up	149.538	9.553

This image also has mean DN and SD of DN minimized at 30 m, with a plateau extending to 60 m.

Nebraska path33row31– Isolated Center Pivots -2002/06/08

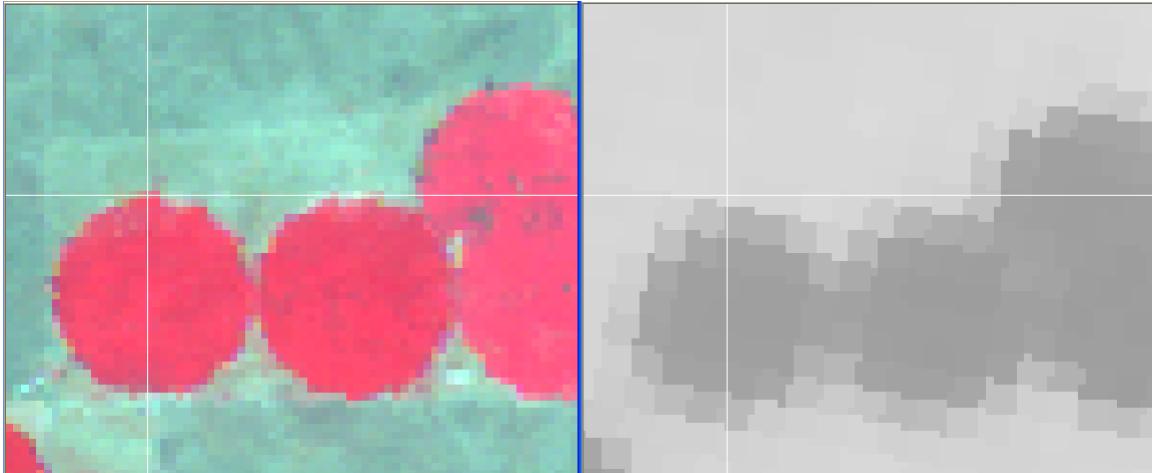


Conclusion

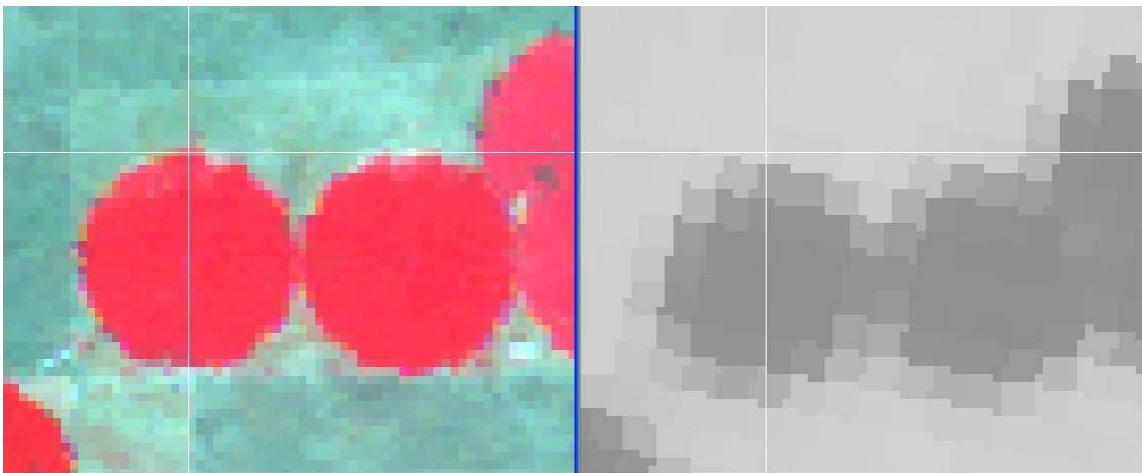
L1T images processed for Landsat 5 (TM) by the EROS Center during 2007 reflect a systematic vertical downward shift of 30 to 90 m in the resampled band 6 (thermal band), where Band 6 was resampled during the L1T process from the original 120 m to 30 m. The shift problem seems to occur for both cubic convolution and nearest neighbor resampling schemes.

Consistency of the systematic shift

The following visual analysis shows the repeatability of the systematic shift. The first image below show false color and NN resampled band 6 for the 7/15/2006 L1T TM5 image for 39/30 used above. This L1T was processed 8/02/2007 by EROS using NLAPS Version 4_11_0e19.



The following screenshot shows the same fields for the same date, but processed 9/24/2007 under a different work order by EROS, but also using NLAPS Version 4_11_0e19.



Visually, the downward shift in band 6 is the same between the two processing dates, indicating consistency in the shift. The upper image was processed as a single path/row (39/30) scene, whereas the bottom image was processed as a double row strip (39/29-30) using a 30% shift to the south. The different ‘start’ position did slightly impact the shapes of some of the band 6 pixels, when resampled to 30 m. However, the impact of this is very minor.

Appendix A.

NLAPS Correction Processing Reports

Idaho

NLAPS CORRECTION PROCESSING REPORT

NLAPS Version: 4_11_0e19
Work Order: 011070801001700003 Priority: 5
Satellite: Landsat-5 Sensor: TM
Camera Number: N/A Sensor Mode: N/A

Input Data Ident: /san/stk1/nlaps/diskIngest/01107080100170003
Input Media Type: Disk File Number: N/A
Orbit Number: 118993

Processing Level: Precision Geocorrection Resampling: NN
Map Projection: TM Zone: N/A
Earth Ellipsoid: NAD83 Panel Effect: FALSE
Product Orient.: Map North

Projection Params:
6.378137000000000e+06 6.356752314140000e+06 9.996000000000000e-01
0.000000000000000e+00 -1.140000000000000e+08 4.200000000000000e+07
2.500000000000000e+06 1.200000000000000e+06 0.000000000000000e+00
0.000000000000000e+00 0.000000000000000e+00 0.000000000000000e+00
0.000000000000000e+00 0.000000000000000e+00 0.000000000000000e+00

Line Spacing: 030.0 Pixel Spacing: 030.0

Path/Strip no.: 039 Start Row no.: 030.0
End Row no.: N/A

Image Lines: 7076 Image Pixels: 7718
Image Orientation: 0.00 deg from N Output Bands: 1234567
Viewing Angle: 0.01 deg

Scene center lat: 43.171 deg Scene center long: -112.563 deg
Sun Elevation: 61.51 deg Sun Azimuth: 131.97 deg
Scene center date: 2006 07 15 Scene center time: 18:06:38.6400

Output Media: Disk Output Product Id: N/A
Product Format: GeoTiff Interleaving : BSQ
Catalogued: FALSE

Completion date: 2007 08 02 Completion time: 7:42:54

Termination Status: Successful Completion

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DETAILED PROCESSING RESULTS

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MODEL REFINEMENT STATISTICS

Number of CPs in model: 28

Error	Mean (m)	RMS (m)	Std Dev (m)
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Along Track	-0.23	6.69	6.68
Across Track	-0.32	7.18	7.18
Height	0.03	0.73	0.73
Combined	0.39	9.84	9.83

Num	Mark	Kind	Location			Residuals			
			Lat	Long	Height	Along	Across	Height	Comb
30115	Auto	RCP	43.82	-112.79	1460.00	-5.33	3.14	-0.17	6.18
24057	Auto	RCP	42.35	-113.04	1697.08	7.70	-11.40	0.29	13.76
11244	Auto	RCP	42.31	-113.99	1398.15	-0.65	6.38	-0.92	6.48
24130	Auto	RCP	44.96	-111.64	1763.57	1.03	8.05	0.29	8.12
9569	Auto	RCP	44.99	-110.80	2433.03	-4.90	11.08	1.51	12.21
10655	Auto	RCP	43.19	-111.59	1951.00	12.79	-0.59	-0.09	12.81
10571	Auto	RCP	43.22	-113.67	1614.64	-3.45	11.16	-1.56	11.79
9972	Auto	SCP	44.39	-113.18	2069.15	0.45	-0.58	0.07	0.74
30134	Auto	RCP	43.23	-112.44	1362.39	-7.92	0.86	0.02	7.97
10857	Auto	SCP	42.65	-111.67	1743.00	-1.35	4.95	0.67	5.18
9657	Auto	SCP	45.20	-112.28	2255.91	-0.20	-3.80	0.20	3.81
10019	Auto	RCP	44.51	-111.00	2613.99	-4.71	-15.01	-1.99	15.85
10852	Auto	SCP	42.80	-112.25	1402.00	-1.90	4.24	0.23	4.65
9942	Auto	RCP	44.82	-112.75	1766.00	7.18	-5.56	0.51	9.10
10017	Auto	RCP	44.67	-111.96	2038.63	6.84	1.23	0.01	6.95
9953	Auto	RCP	44.34	-112.66	2136.18	-9.48	-2.60	0.17	9.83
30135	Auto	RCP	42.68	-112.66	1522.04	-15.09	-0.18	0.00	15.09
25710	Auto	RCP	43.13	-112.04	1719.16	2.87	7.36	0.48	7.91
30114	Auto	RCP	43.89	-113.20	1775.45	-4.36	3.25	-0.35	5.45
10594	Auto	SCP	43.22	-112.99	1551.13	-6.16	-12.46	0.70	13.92
9892	Auto	SCP	44.78	-111.15	2005.79	10.81	-5.62	-0.59	12.20
10237	Man	RCP	43.70	-111.55	1829.29	-7.00	-7.74	-0.78	10.47
10668	Man	RCP	42.71	-113.78	1285.61	5.17	-6.85	0.91	8.63
10566	Man	SCP	43.55	-112.50	1586.98	-8.11	-9.14	0.08	12.22
10328	Man	RCP	43.83	-111.96	1475.00	-0.64	5.78	0.27	5.83
10564	Man	RCP	43.64	-113.40	1646.00	6.62	-8.09	0.99	10.50
37430	Man	RCP	43.46	-111.73	1557.75	6.66	6.48	0.58	9.31
10874	Man	RCP	42.99	-113.35	1447.23	6.75	6.81	-0.63	9.61

RADIOMETRIC CORRECTION

Algorithm: NASA CPF

Band	Ref Detector	DN to Radiance		Default Abs Calib?
		gain	offset	
1	15	0.762824	-1.520000	FALSE
2	10	1.442510	-2.840000	FALSE
3	2	1.039880	-1.170000	FALSE

4	1	0.872588	-1.510000	FALSE
5	2	0.119882	-0.370000	FALSE
6	4	0.055158	1.237800	FALSE
7	15	0.065294	-0.150000	FALSE

Band 1 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.941693	0.658849	0.934614	1.368920
2	0.935880	0.959433	0.930633	1.518460
3	0.927484	0.851004	0.920110	1.568670
4	0.936050	0.846631	0.930058	1.496730
5	0.933316	1.089960	0.929353	1.554700
6	0.938551	0.749208	0.933514	1.323080
7	0.937201	0.715357	0.932460	1.251550
8	0.924914	1.331030	0.923431	1.594550
9	0.924950	1.022930	0.921019	1.518800
10	0.928856	1.446910	0.927853	1.707800
11	0.926948	0.948243	0.924120	1.365730
12	0.938030	1.144940	0.936422	1.462420
13	0.931938	0.960942	0.930089	1.297020
14	0.939052	1.369430	0.937948	1.645660
15	0.932445	1.436620	0.930727	1.781720
16	0.944345	1.210750	0.940568	1.752430

Band 2 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.926514	1.187570	0.915474	1.702120
2	0.942853	0.896350	0.928803	1.510130
3	0.931353	0.995035	0.918702	1.569150
4	0.935872	0.982947	0.920092	1.668540
5	0.942370	0.767773	0.929048	1.365560
6	0.934838	1.139350	0.925723	1.563170
7	0.932166	0.849928	0.920236	1.384230
8	0.920066	1.323650	0.910723	1.754900
9	0.936116	1.299060	0.928226	1.679290
10	0.923922	1.114410	0.915079	1.536010
11	0.933003	0.979556	0.924537	1.388650
12	0.927853	0.906766	0.922144	1.230380
13	0.930501	0.562191	0.921040	1.021360
14	0.923947	1.288640	0.916751	1.654520
15	0.934802	0.712600	0.925705	1.173300
16	0.937117	1.466090	0.927041	1.971330

Band 3 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.955369	1.680590	0.947845	2.168950
2	0.945457	1.919780	0.939739	2.332770

3	0.949093	1.703110	0.944483	2.074040
4	0.928987	2.273600	0.920444	2.779710
5	0.951303	1.656100	0.944317	2.137010
6	0.932277	2.201810	0.924350	2.710700
7	0.933774	2.405120	0.928022	2.772460
8	0.939491	1.888450	0.931926	2.415660
9	0.939482	2.179270	0.937620	2.391320
10	0.929074	2.018060	0.927727	2.277050
11	0.931498	2.327650	0.927574	2.663710
12	0.944987	2.011720	0.944799	2.205060
13	0.943106	2.041330	0.940060	2.345990
14	0.938117	2.234730	0.936041	2.499290
15	0.956782	1.812820	0.955455	2.091390
16	0.943229	2.639690	0.942669	2.874740

Band 4 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.942795	1.977220	0.947908	1.609660
2	0.941562	1.760790	0.943621	1.620460
3	0.946867	1.872900	0.949883	1.665680
4	0.936986	2.122300	0.941156	1.823770
5	0.944189	1.613980	0.947511	1.389460
6	0.950826	1.557450	0.953733	1.351380
7	0.954141	1.615500	0.955889	1.470400
8	0.933498	2.191240	0.936766	1.943310
9	0.950622	2.105160	0.952087	1.971800
10	0.946275	2.506110	0.947965	2.338540
11	0.946487	1.947770	0.948754	1.742750
12	0.937756	2.454310	0.939616	2.308550
13	0.929587	2.084390	0.933133	1.817640
14	0.936304	2.296320	0.940342	1.979660
15	0.940413	2.111180	0.944361	1.829760
16	0.943865	3.065480	0.947596	2.789300

Band 5 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.962496	-1.558130	0.955677	-0.400876
2	0.959716	-1.536670	0.951003	-0.192326
3	0.953567	-0.943803	0.945910	0.286335
4	0.958956	-1.135810	0.951904	0.033119
5	0.957114	-1.060450	0.950862	0.038047
6	0.953532	-1.002010	0.948344	-0.057923
7	0.943499	-0.810050	0.937930	0.146004
8	0.959699	-1.182040	0.954231	-0.246029
9	0.972297	-0.593978	0.967245	0.314723
10	0.945149	-1.238770	0.941859	-0.543514
11	0.947541	-1.065600	0.944259	-0.352341
12	0.960556	-0.964954	0.958516	-0.382564
13	0.939333	-0.927025	0.937413	-0.351884
14	0.953848	-0.780971	0.952844	-0.296056
15	0.944006	-0.738830	0.943659	-0.282471

16	0.961527 -0.753781	0.960180 -0.180270
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Band 6 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	1.209610	-26.273200	1.209610	-26.017700
2	1.238060	-31.213200	1.238060	-30.986400
3	1.206190	-25.949600	1.206190	-25.774000
4	1.283910	-36.831200	1.283910	-36.535200

Band 7 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.956141	-0.324260	0.951305	0.208336
2	0.957734	-0.482681	0.950860	0.147648
3	0.946830	-0.186929	0.940645	0.400510
4	0.949063	-0.196607	0.942714	0.396221
5	0.948271	-0.286022	0.943045	0.257924
6	0.958882	-0.052855	0.953940	0.462373
7	0.940675	-0.153190	0.936029	0.335249
8	0.955001	0.021455	0.950783	0.487780
9	0.942089	-0.005652	0.938479	0.443144
10	0.945516	0.077611	0.942878	0.471459
11	0.931836	0.020069	0.929641	0.399014
12	0.955286	0.219472	0.953828	0.557595
13	0.951173	0.013059	0.950370	0.327206
14	0.950468	0.149286	0.950227	0.439124
15	0.941792	-0.042359	0.942854	0.212478
16	0.953300	0.364368	0.953200	0.683150

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DEM PROCESSING

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Elevation Correction Applied: Fine DEM
LineSpacing: 1.00000000000000e+00
LineSpacingUnits: seconds
PixelSpacing: 1.00000000000000e+00
PixelSpacingUnits: seconds

DEM Files Used

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n42w125_n49w96

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GEOMETRIC QUALITY ASSESSMENT

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Number of QA CPs: 12

Error	Mean (m)	RMS (m)	Std Dev (m)
Along Track	-3.23	8.21	7.54
Across Track	-3.69	7.72	6.78
Height	0.00	0.00	0.00
Combined	4.91	11.27	10.14

Num	Mark	Kind	Location			Residuals			
			Lat	Long	Height	Along	Across	Height	Comb
11240	Man	RCP	42.47	-111.78	1505.96	7.51	-0.13	0.00	7.52
30128	Man	RCP	43.01	-112.83	1356.00	-7.51	0.00	0.00	7.51
10873	Auto	SCP	42.66	-113.02	1285.22	0.40	-14.08	0.00	14.09
10850	Auto	RCP	42.97	-111.78	1840.71	-17.76	-4.03	0.00	18.21
30137	Auto	RCP	43.36	-112.64	1496.07	-3.90	5.33	0.00	6.61
30133	Auto	RCP	43.20	-112.36	1366.61	-10.40	5.99	0.00	12.00
30121	Man	RCP	43.62	-112.05	1448.90	-7.51	-15.00	0.00	16.78
10593	Auto	SCP	43.56	-113.52	1756.73	-6.34	-10.02	0.00	11.86
10565	Man	RCP	43.18	-113.50	1490.85	-7.50	-7.50	0.00	10.60
10551	Auto	SCP	43.42	-111.79	1707.00	-0.16	2.19	0.00	2.20
30111	Man	RCP	44.01	-113.24	1699.30	7.50	-0.00	0.00	7.50
10270	Auto	SCP	43.92	-112.75	1505.41	6.87	-7.05	0.00	9.85

RADIOMETRIC QUALITY ASSESSMENT

NOTE:

Mean, Std.Dev, Striping are in DN's (Digital Numbers).

Band	Chip Location		Chip Size		Mean	Std Dev	Striping
	Line	Pixel	Lines	Pixels			
1	2378.40	1268.00	128	128	0.73	0.061	0.0027
1	4755.80	2535.00	128	128	0.70	0.032	0.0019
1	7133.20	3802.00	128	128	0.73	0.008	0.0008
1	9510.60	5069.00	128	128	1.51	0.259	0.0102
2	2378.40	1268.00	128	128	0.35	0.035	0.0018
2	4755.80	2535.00	128	128	0.35	0.030	0.0016
2	7133.20	3802.00	128	128	0.33	0.003	0.0007
2	9510.60	5069.00	128	128	0.67	0.109	0.0033
3	2378.40	1268.00	128	128	0.41	0.039	0.0028
3	4755.80	2535.00	128	128	0.35	0.083	0.0050
3	7133.20	3802.00	128	128	0.36	0.009	0.0008
3	9510.60	5069.00	128	128	0.71	0.097	0.0030
4	2378.40	1268.00	128	128	0.65	0.030	0.0016
4	4755.80	2535.00	128	128	1.15	0.162	0.0081
4	7133.20	3802.00	128	128	0.56	0.168	0.0081
4	9510.60	5069.00	128	128	0.98	0.047	0.0022
5	2378.40	1268.00	128	128	1.31	0.206	0.0116
5	4755.80	2535.00	128	128	1.19	0.109	0.0036
5	7133.20	3802.00	128	128	1.00	0.068	0.0028
5	9510.60	5069.00	128	128	1.09	0.046	0.0026
6	595.20	318.40	128	128	1.65	0.040	0.0023

6	1189.40	635.80	128	128	1.74	0.043	0.0020
6	1783.60	953.20	128	128	1.61	0.048	0.0017
6	2377.80	1270.60	128	128	1.27	0.179	0.0047
7	2378.40	1268.00	128	128	0.72	0.097	0.0097
7	4755.80	2535.00	128	128	0.55	0.114	0.0046
7	7133.20	3802.00	128	128	0.49	0.051	0.0028
7	9510.60	5069.00	128	128	0.54	0.036	0.0011

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PRODUCT FORMATTING

Product Scene Center Location (lat/long) : 43.171 -112.563
 Product Scene Center Date/Time (yyyy mm dd): 2006 7 15 18:06:38.6400

Product Extent:

Lat:	44.14	-----	Lat:	44.10
Long:	-113.99		Long:	-111.09
North:	1437120.00		North:	1437120.00
East:	2501070.00		East:	2732580.00
Lat:	42.22	-----	Lat:	42.19
Long:	-113.99		Long:	-111.18
North:	1224870.00		North:	1224870.00
East:	2501070.00	-----	East:	2732580.00

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EXECUTION INFORMATION

Stage	Start	End	CPU
Ingest	Wed Aug 1 15:38:02 2007	Wed Aug 1 15:39:09 2007	54.77
ModelRefiner	Wed Aug 1 15:40:45 2007	Wed Aug 1 15:48:07 2007	17.15
MemEffect	Wed Aug 1 15:49:24 2007	Wed Aug 1 16:01:01 2007	521.58
DemIngest	Wed Aug 1 15:48:10 2007	Wed Aug 1 15:49:09 2007	9.07
WarpDem	Wed Aug 1 15:49:09 2007	Wed Aug 1 15:49:24 2007	10.39
ImCorr	Wed Aug 1 16:01:02 2007	Wed Aug 1 16:04:51 2007	447.33
RadQa	Wed Aug 1 16:04:51 2007	Wed Aug 1 16:04:51 2007	0.18
GeoQa	Wed Aug 1 16:08:48 2007	Thu Aug 2 07:42:31 2007	2.99
Output	Thu Aug 2 07:42:32 2007	Thu Aug 2 07:42:52 2007	4.45
Catalog	Thu Aug 2 07:42:53 2007	Thu Aug 2 07:42:53 2007	0.43

1068.34

Nebraska

NLAPS CORRECTION PROCESSING REPORT

NLAPS Version: 4_11_0e19
Work Order: 080071017007300002 Priority: 5
Satellite: Landsat-5 Sensor: TM
Camera Number: N/A Sensor Mode: N/A

Input Data Ident: /san/stk1/nlaps/diskIngest/08007101700730002
Input Media Type: Disk File Number: N/A
Orbit Number: 97178

Processing Level: Precision Geocorrection Resampling: NN
Map Projection: UTM Zone: 13
Earth Ellipsoid: NAD83 Panel Effect: FALSE
Product Orient.: Map North

Projection Params:
6.378137000000000e+06 6.356752314250000e+06 0.000000000000000e+00
0.000000000000000e+00 0.000000000000000e+00 0.000000000000000e+00
0.000000000000000e+00 0.000000000000000e+00 0.000000000000000e+00
0.000000000000000e+00 0.000000000000000e+00 0.000000000000000e+00
0.000000000000000e+00 0.000000000000000e+00 0.000000000000000e+00

Line Spacing: 030.0 Pixel Spacing: 030.0

Path/Strip no.: 033 Start Row no.: 031.0
End Row no.: N/A

Image Lines: 7061 Image Pixels: 7726
Image Orientation: 0.00 deg from N Output Bands: 1234567
Viewing Angle: 0.01 deg

Scene center lat: 41.770 deg Scene center long: -103.895 deg
Sun Elevation: 61.76 deg Sun Azimuth: 123.61 deg
Scene center date: 2002 06 08 Scene center time: 17:13:20.3825

Output Media: Disk Output Product Id: N/A
Product Format: NDF Interleaving : BSQ
Catalogued: FALSE

Completion date: 2007 10 22 Completion time: 11:43:17

Termination Status: Successful Completion

DETAILED PROCESSING RESULTS

MODEL REFINEMENT STATISTICS

Number of CPs in model: 20

Error	Mean (m)	RMS (m)	Std Dev (m)
Along Track	0.47	6.11	6.09
Across Track	-0.14	5.48	5.47
Height	-0.02	0.38	0.37
Combined	0.49	8.21	8.20

Num	Mark	Kind	Location			Residuals			
			Lat	Long	Height	Along	Across	Height	Comb
10982	Auto	SCP	42.28	-103.62	1429.89	4.38	9.49	0.13	10.45
12032	Auto	SCP	40.54	-103.46	1310.64	5.36	7.24	0.77	9.04
10846	Auto	SCP	42.63	-102.81	1226.33	10.11	-5.90	-0.60	11.72
11869	Auto	RCP	40.71	-104.60	1579.30	9.31	-1.58	0.07	9.45
10685	Auto	SCP	42.86	-103.40	1087.94	0.67	-0.65	-0.01	0.94
30520	Auto	RCP	42.05	-104.97	1466.10	-10.92	5.08	-0.73	12.07
33320	Auto	RCP	41.48	-102.89	1192.38	-2.74	-1.37	-0.19	3.07
11527	Auto	RCP	41.54	-104.16	1463.00	6.99	10.75	-0.26	12.83
30604	Auto	RCP	41.13	-103.68	1486.37	-3.74	-4.27	-0.23	5.68
11756	Auto	RCP	41.05	-103.06	1332.67	-9.74	-3.44	-0.45	10.34
30606	Auto	RCP	41.39	-104.66	1805.00	8.17	-3.81	0.30	9.02
11501	Auto	SCP	41.48	-103.68	1493.85	7.03	4.60	0.18	8.40
11598	Auto	RCP	41.12	-104.84	1871.00	-8.37	-3.07	0.30	8.92
10978	Auto	RCP	42.03	-104.10	1262.67	2.53	-6.98	0.26	7.43
11757	Auto	SCP	41.25	-103.32	1372.74	-0.77	-3.38	-0.32	3.49
11300	Auto	SCP	41.66	-103.16	1145.48	-2.64	-3.68	-0.36	4.54
11528	Auto	RCP	41.81	-104.05	1286.45	-0.25	-6.80	0.15	6.80
11024	Auto	SCP	42.06	-103.62	1402.00	-1.15	-5.33	-0.12	5.46
11562	Auto	RCP	41.09	-104.06	1645.94	-4.77	4.80	0.03	6.77
30602	Man	RCP	42.13	-102.84	1198.00	-0.05	5.44	0.64	5.48

RADIOMETRIC CORRECTION

Algorithm: NASA CPF

Band	Ref Detector	DN to Radiance		Default Abs Calib?
		gain	offset	
1	15	0.762824	-1.520000	FALSE
2	10	1.442510	-2.840000	FALSE
3	2	1.039880	-1.170000	FALSE
4	1	0.872588	-1.510000	FALSE
5	2	0.119882	-0.370000	FALSE
6	4	0.055158	1.237800	FALSE
7	15	0.065294	-0.150000	FALSE

Band 1 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.949098	1.395670	0.959433	0.570300
2	0.931665	2.989870	0.944514	1.585340

3	0.928328	2.646110	0.940055	1.330510
4	0.943843	1.285240	0.952544	0.779656
5	0.935630	2.861000	0.947294	1.561560
6	0.937844	2.250110	0.949201	1.179490
7	0.937884	2.192070	0.947205	1.408670
8	0.928795	2.595720	0.939245	1.532300
9	0.924507	2.479090	0.931760	1.970800
10	0.930316	2.749680	0.940940	1.731270
11	0.925735	2.526850	0.933570	1.934930
12	0.938649	2.675400	0.949976	1.587370
13	0.928695	2.827320	0.940112	1.654070
14	0.935930	3.215850	0.945863	2.073710
15	0.933914	3.061860	0.944711	1.867670
16	0.939928	3.090900	0.949047	2.443320

Band 2 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.936420	1.604620	0.930764	2.221100
2	0.945563	1.959410	0.944639	2.093560
3	0.935617	2.035200	0.934439	2.207300
4	0.937308	2.198820	0.935229	2.463590
5	0.944055	2.073630	0.945471	1.984710
6	0.934422	2.519670	0.934402	2.574410
7	0.939202	1.819740	0.936840	2.126470
8	0.936062	1.455700	0.926845	2.405090
9	0.952383	1.507040	0.947265	2.048550
10	0.929856	2.110580	0.928119	2.349880
11	0.929044	2.573430	0.930038	2.548180
12	0.936561	1.611250	0.933066	2.051480
13	0.935676	1.655900	0.933846	1.936100
14	0.931244	1.963910	0.924383	2.694480
15	0.939157	1.844460	0.938114	2.026070
16	0.939489	2.259300	0.932524	3.041230

Band 3 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.949108	3.395500	0.951686	3.258440
2	0.944461	3.031790	0.943561	3.247270
3	0.948567	2.794400	0.946972	3.090470
4	0.939031	2.429190	0.934038	3.053990
5	0.946058	3.244910	0.947751	3.198990
6	0.927717	3.707620	0.927966	3.857960
7	0.946772	2.463880	0.942750	2.957030
8	0.944965	1.811530	0.935729	2.927160
9	0.941525	3.146720	0.939469	3.603730
10	0.929921	2.852620	0.925132	3.510670
11	0.938135	2.650370	0.931362	3.526620
12	0.942862	3.050140	0.940639	3.419980
13	0.946613	2.649450	0.940127	3.444680
14	0.930307	3.948390	0.932415	3.792950
15	0.943898	4.123760	0.945551	4.035620

16		0.936408	4.119510	0.936897	4.176220
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Band 4 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.952075	2.060380	0.948137	2.509740
2	0.951733	2.346060	0.952281	2.256600
3	0.949403	2.489950	0.950453	2.373230
4	0.941534	2.448170	0.938318	2.818120
5	0.946913	2.178260	0.948166	2.026220
6	0.944619	2.685880	0.943490	2.799470
7	0.955043	2.336760	0.957043	2.099650
8	0.933062	2.967250	0.931553	3.169430
9	0.953334	2.684220	0.952097	2.873640
10	0.938092	3.948680	0.937709	4.041870
11	0.945832	2.653350	0.945883	2.694850
12	0.935582	3.508770	0.937520	3.343940
13	0.937293	2.008800	0.935919	2.241950
14	0.933476	3.366640	0.933559	3.403080
15	0.944936	2.510870	0.943639	2.722700
16	0.944512	3.756990	0.949291	3.222190

Band 5 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.951140	-1.081120	0.951304	-1.142610
2	0.947481	-1.050040	0.946826	-0.977078
3	0.942753	-0.559984	0.942400	-0.551141
4	0.945886	-0.699069	0.946001	-0.772314
5	0.944535	-0.557170	0.944662	-0.629756
6	0.940564	-0.622471	0.940687	-0.687741
7	0.937579	-0.379380	0.937055	-0.347791
8	0.943732	-0.625234	0.944041	-0.737867
9	0.959496	-0.012722	0.960114	-0.167882
10	0.929498	-0.626996	0.930679	-0.863366
11	0.933434	-0.331160	0.934343	-0.526230
12	0.947941	-0.371104	0.949295	-0.636018
13	0.927674	-0.327693	0.928272	-0.484035
14	0.942415	-0.238329	0.943179	-0.443875
15	0.935534	-0.211043	0.935459	-0.280976
16	0.952047	-0.283689	0.950978	-0.182504

Band 6 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.685602	26.187500	0.685602	25.672800
2	0.723882	21.169600	0.723882	20.651300
3	0.684879	26.184600	0.684879	25.670500
4	0.749011	18.270900	0.749011	17.508700

Band 7 Coefficients (Qcal = (Q - offset) / gain):

Detector	Forward		Backward	
	gain	offset	gain	offset
1	0.937493	-0.214504	0.931468	0.191049
2	0.940683	-0.550135	0.933273	-0.028964
3	0.928434	-0.122038	0.921912	0.315294
4	0.931153	-0.126523	0.925372	0.244242
5	0.929771	-0.173215	0.923717	0.226435
6	0.941158	-0.052376	0.935587	0.308885
7	0.922565	-0.015813	0.916409	0.393355
8	0.937760	-0.034157	0.931733	0.346182
9	0.925058	0.055834	0.919016	0.447220
10	0.929332	0.003443	0.923437	0.382340
11	0.915790	0.093925	0.910043	0.463687
12	0.940644	0.337879	0.935124	0.684459
13	0.936197	0.083635	0.930361	0.455918
14	0.936718	0.182334	0.930728	0.560527
15	0.926932	-0.055922	0.921286	0.295990
16	0.939834	0.290860	0.932533	0.791834

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DEM PROCESSING

Elevation Correction Applied: Fine DEM

LineSpacing: 1.00000000000000e+00

LineSpacingUnits: seconds

PixelSpacing: 1.00000000000000e+00

PixelSpacingUnits: seconds

DEM Files Used

n32w125_n42w96
n42w125_n49w96

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GEOMETRIC QUALITY ASSESSMENT

Number of QA CPs: 9

Error	Mean (m)	RMS (m)	Std Dev (m)
Along Track	0.98	7.76	7.70
Across Track	2.35	3.56	2.67
Height	0.00	0.00	0.00
Combined	2.55	8.53	8.14

Num	Mark	Kind	Location			Residuals			
			Lat	Long	Height	Along	Across	Height	Comb

30603	Auto	RCP	41.24	-103.66	1429.70	0.19	5.94	0.00	5.94
11605	Man	RCP	41.10	-104.35	1664.08	7.50	0.00	0.00	7.50
11509	Man	RCP	41.92	-103.06	1281.75	0.00	0.00	0.00	0.00
11446	Auto	SCP	41.43	-103.33	1319.73	3.31	3.67	0.00	4.94
11434	Man	SCP	41.67	-104.42	1524.00	-0.00	-0.00	0.00	0.00
11285	Man	RCP	41.89	-103.64	1189.62	14.99	0.01	0.00	14.99
30601	Man	RCP	42.22	-102.82	1214.13	-7.50	7.51	0.00	10.61
30521	Auto	RCP	42.12	-104.88	1381.00	-13.40	2.53	0.00	13.64
10999	Auto	RCP	42.43	-103.73	1340.86	3.71	1.50	0.00	4.00

RADIOMETRIC QUALITY ASSESSMENT

NOTE:

Mean, Std.Dev, Striping are in DN's (Digital Numbers).

Band	Chip Location Line	Chip Location Pixel	Chip Size Lines	Chip Size Pixels	Mean	Std Dev	Striping
1	2407.20	1268.00	128	128	2.13	0.102	0.0032
1	4813.40	2535.00	128	128	2.18	0.132	0.0098
1	7219.60	3802.00	128	128	1.12	0.089	0.0057
1	9625.80	5069.00	128	128	0.97	0.021	0.0018
2	2407.20	1268.00	128	128	0.97	0.067	0.0015
2	4813.40	2535.00	128	128	1.00	0.069	0.0046
2	7219.60	3802.00	128	128	0.55	0.056	0.0028
2	9625.80	5069.00	128	128	0.49	0.017	0.0016
3	2407.20	1268.00	128	128	1.04	0.104	0.0060
3	4813.40	2535.00	128	128	1.14	0.087	0.0064
3	7219.60	3802.00	128	128	0.67	0.098	0.0054
3	9625.80	5069.00	128	128	0.64	0.037	0.0031
4	2407.20	1268.00	128	128	1.00	0.108	0.0074
4	4813.40	2535.00	128	128	1.16	0.063	0.0034
4	7219.60	3802.00	128	128	0.82	0.097	0.0025
4	9625.80	5069.00	128	128	0.82	0.035	0.0032
5	2407.20	1268.00	128	128	1.24	0.090	0.0091
5	4813.40	2535.00	128	128	1.36	0.015	0.0011
5	7219.60	3802.00	128	128	1.43	0.242	0.0035
5	9625.80	5069.00	128	128	1.71	0.061	0.0049
6	602.40	318.40	128	128	0.79	0.052	0.0034
6	1203.80	635.80	128	128	0.57	0.117	0.0087
6	1805.20	953.20	128	128	1.60	0.033	0.0045
6	2406.60	1270.60	128	128	1.67	0.019	0.0025
7	2407.20	1268.00	128	128	0.61	0.069	0.0063
7	4813.40	2535.00	128	128	0.69	0.008	0.0008
7	7219.60	3802.00	128	128	0.80	0.187	0.0039
7	9625.80	5069.00	128	128	0.97	0.072	0.0022

PRODUCT FORMATTING

Product Scene Center Location (lat/long) : 41.770 -103.895
 Product Scene Center Date/Time (yyyy mm dd): 2002 6 8 17:13:20.3825

Product Extent:

Lat:	42.73	-----	Lat:	42.70
Long:	-105.29		Long:	-102.46
North:	4730730.00		North:	4730730.00
East:	475950.00		East:	707700.00

Lat:	40.82	-----	Lat:	40.80
Long:	-105.29		Long:	-102.54
North:	4518930.00		North:	4518930.00
East:	475950.00	-----	East:	707700.00

EXECUTION INFORMATION

Stage	Start	End	CPU

Ingest	Mon Oct 22 09:41:58 2007	Mon Oct 22 09:43:24 2007	59.76
ModelRefiner	Mon Oct 22 09:43:30 2007	Mon Oct 22 10:51:42 2007	54.47
MemEffect	Mon Oct 22 10:52:16 2007	Mon Oct 22 11:01:59 2007	534.01
DemIngest	Mon Oct 22 10:51:45 2007	Mon Oct 22 10:52:08 2007	8.92
WarpDem	Mon Oct 22 10:52:08 2007	Mon Oct 22 10:52:16 2007	10.15
ImCorr	Mon Oct 22 11:01:59 2007	Mon Oct 22 11:05:50 2007	425.43
RadQa	Mon Oct 22 11:05:50 2007	Mon Oct 22 11:05:50 2007	0.18
GeoQa	Mon Oct 22 11:05:51 2007	Mon Oct 22 11:42:41 2007	6.14
Output	Mon Oct 22 11:42:42 2007	Mon Oct 22 11:43:15 2007	5.59
Catalog	Mon Oct 22 11:43:15 2007	Mon Oct 22 11:43:15 2007	0.49

			1105.14